Design and Analysis of Rotor Shaft Assembly of A Head Pulley Using ANSYS

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Abstract- *The large solid particles are reduced to smaller particles using crushers. Crushers are functional to bring down the size, or change the shape of the material so that they can be more easily disposed of or recycled, or to reduce the size of a raw materials (as in rock ore), so that different pieces of various composition can be sorted out. In these crushing devices the material will be held between two parallel or tangent solid surfaces, and required force is applied to bring the rollers together to generate enough energy within the material being crushed.*

In this paper design and analysis of rotor shaft assembly for head pulley crusher is carried out. The head pulley crusher has the capacity of 0.1 (100kg/hr) tones per hour and transmitting 20 B.H.P at a speed of 750 rpm. Standard design procedure is used for the design of rotor shaft assembly. In the present work by using the standard design procedure, diameter of rotor shaft of head pulley crusher has been designed. The design of the rotor shaft assembly must be safe when the stress and deflection values obtained from the present design procedure are compared with the values and results obtained from the analysis using Ansys package. The bending of the shaft should be avoided when it rotating at the designed rpm. Model analysis was performed to understand the vibration characteristics of the rotor shaft assembly

Keywords- Head pulley crusher, Structural analysis.

I. INTRODUCTION

Crushing is the way toward exchanging a power increased by mechanical preferred standpoint through a material made of particles that bond together more emphatically, and oppose distortion more, than those in the material being smashed do. Smashing gadgets hold material between two parallel or digression strong surfaces, and apply adequate power to unite the surfaces to create enough vitality inside the material being squashed with the goal that its atoms isolate from (cracking), or change arrangement in connection to (disfigurement), each other. The most punctual crushers were hand-held stones, where the heaviness of the stone gave a lift to muscle control, utilized against a stone iron block. Querns and mortars are kinds of these devastating gadgets.

A crusher is a machine intended to diminish expansive strong material items into a littler volume, or littler pieces. Crushers might be utilized to diminish the size, or change the frame, of waste materials so they can be all the more effortlessly discarded or reused, or to decrease the span of a strong blend of crude materials (as in shake metal), with the goal that bits of various piece can be separated. Smashing is the way toward exchanging a power enhanced by mechanical preferred standpoint through a material made of particles that bond together more unequivocally, than those in the material being pounded do. Smashing gadgets hold material between two parallel or digression strong surfaces, and apply adequate power to unite the surfaces to produce enough vitality inside the material being squashed with the goal that its atoms isolate from (cracking), or change arrangement in connection to (distortion), each other. The soonest crushers were hand-held stones, where the heaviness of the stone gave a lift to muscle control, utilized against a stone blacksmith's iron. Querns and mortars are sorts of these devastating gadgets.

II. METHODOLOGY

The main objective of the paper is to accomplish structural analysis on head pulley crusher which is used in an industrial application for crushing the coal which the particles are grater in size.

For doing the above process design suitability is considered from the references and by using nx-cad the design is completed and by using Ansys software Ansys simulation is done on hammer crush miller.

- A hammer crush is considered of having different components, all the components are designed using Nx-cad software.
- Each component is assembled using Nx assembly.
- The total assembly is formatted into new format file which can be imported into Ansys software to perform structural analysis.
- A structural analysis is performed on the total assembly to know the deflections and stresses which are accomplished due to the load applied on the component.

- The results are tabulated for the material steel.
- All the results are tabulated and compared and the best suitable material is chosen for hammer crush mill.

III. 3D MODELING OF ROTOR SHAFT

The outline depended on the way toward permitting the solid and tough materials of sledge plant to beat any biomass materials that discourage pound process path amid operation. Hence, the outcome was breaking the biomass material which can be eluded as size lessening operation. This operation for the most part happens in a shut chamber called the devastating chamber. The physical and mechanical properties of the smashed material were concentrated to help colossally in the plan of different parts of the rotor.

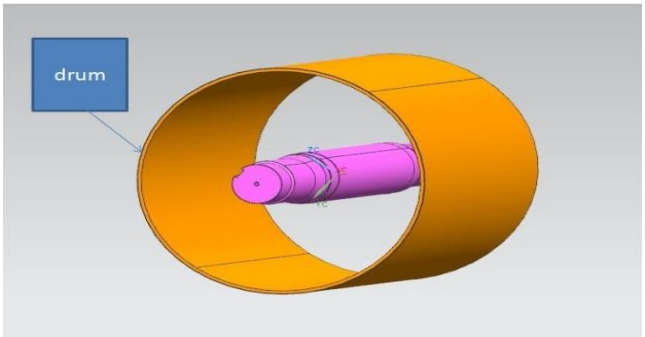

Figure.1. shows the drum part of a rotor shaft assembly of head pulley crusher.

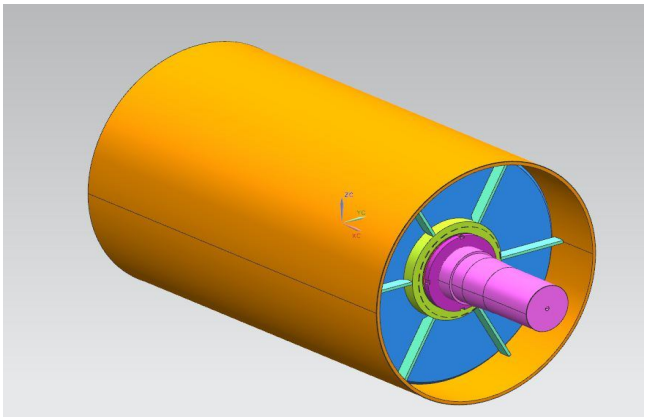

Figure.2. shows the Isometric view of total model.

FINITE ELEMENT ANALYSIS OF ROTOR SHAFT ASSEMBLY OF HEAD PULLEY CRUSHER:

Finite Element Modeling (FEM) and Finite Element Analysis (FEA) are two most well known mechanical designing applications offered by existing CAE frameworks. This is credited to the way that the FEM is maybe the most well known numerical system for tackling designing issues. The strategy is sufficiently general to deal with any perplexing state of geometry (issue area), any material properties, any limit conditions and any stacking conditions. The all inclusive statement of the FEM fits the investigation prerequisites of the present complex building frameworks and plans where shut shape arrangements are administering balance conditions are not accessible. Likewise it is a productive plan apparatus by which creators can perform parametric outline examining different cases (diverse shapes, material burdens and so on.) dissecting them and picking the ideal outline.

FINITE ELEMENT METHOD:

The FEM is numerical examination system for getting inexact answers for wide assortment of building issues. The technique started in the avionic business as an instrument to ponder worries in confused airframe structures. It became out of what was known as the grid examination technique utilized as a part of air ship plan. The technique has picked up fame among the two analysts and experts and after such a significant number of improvements codes are created for wide assortment of issues.

LOAD CALCULATIONS FOR CRUSHER:

Load applied due to Tension T1 : 140 KN
Load applied due to Tension T2 : 88 KN
Dia.of Pulley : 1360 mm
Width of Pulley : 2200 mm

Surface Area of pulley in contact with belt (180^0):

Surface area (A) of pulley on each tight and slack slide:

(¶DL)/4=(3.14*1360*2200)/4 = 2348720mm^2
Pressure applied due to Tension T1: T1/A = $140*10^3/2348720$ N / mm^2
= 0.0596 N / mm^2
Pressure applied due to Tension T2: T2/A = $88*10^3/2348720$ N / mm^2
=0.03746 N / mm2

ANALYSIS OF THE SPROCKET IN ANSYS SOFTWARE:

The 3d model of sprocket is made in the NX-7.5 and then it is converted in the parasolid file.

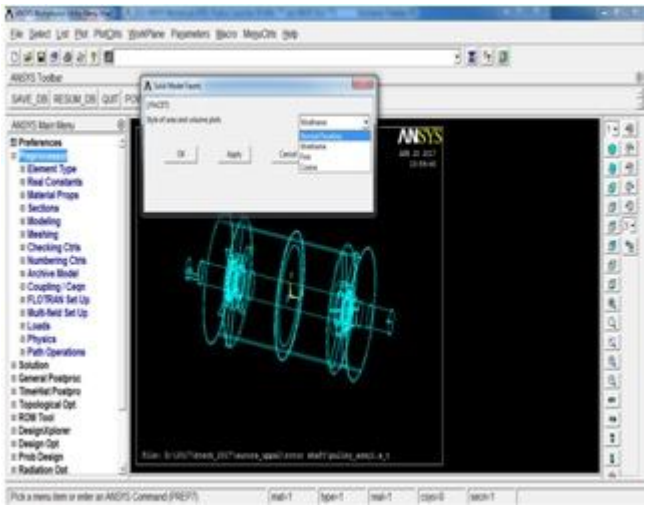

Figure.3. shows the model of sprocket in the NX-7.5

Now using volume command we can see the total body in 3D, below figure presents the 3D model hammer crush mill in Ansys.

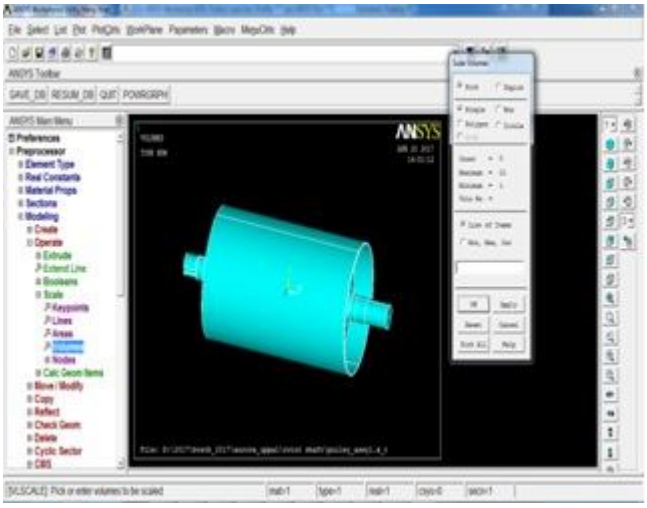

Figure.4. shows the 3D model hammer crush mill in Ansys.

MATERIAL PROPERTIES:

The material used in the construction of rotor shaft assembly is structural steel. So during the analysis in Ansys all components of rotor shaft assembly are assigned with steel properties as shown below.

Table.1. shows the properties of the material.

Property	Value
Young's Modulus	2.1 E5 Mpa
Poisson's Ratio	0.3
Density	7850 Kg/m3
Yield Stress	250 Mpa
Ultimate Stress	390 Mpa

MESHING:

The rotor shaft assembly is meshed using solid 10 node 92 element type. The element geometry and description is given below.

The meshing in analysis produced 91973 elements and 166127 nodes. The meshed model is shown in the below figures.

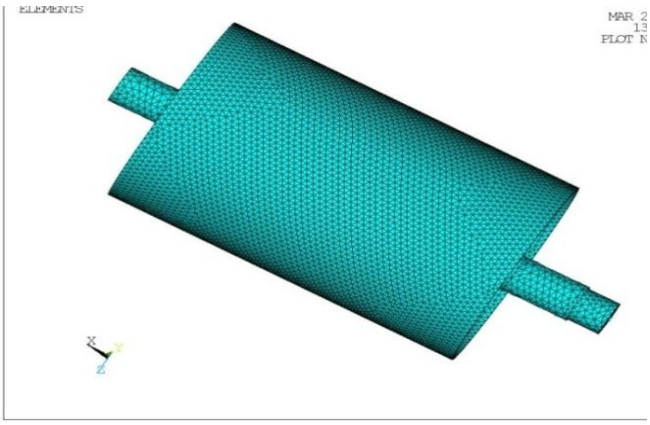

Figure.5. shows the meshed model Rotor Shaft.

BOUNDARY CONDITIONS AND LOADING:

The following are the boundary conditions and loading applied on the rotor shaft assembly:

- Pressure of 0.0596 N/mm^2 is applied on the drum due to load acting from Tension T1 as shown in the below figure.
- Pressure of 0.03746 N/mm^2 is applied in this region due to load acting from Tension T2 as shown in the below figure.
- Shaft is constrained in UX, UY &UZ direction as shown in the below figure.
- One face of the shaft is constrained in rotation X as shown in the below figure.

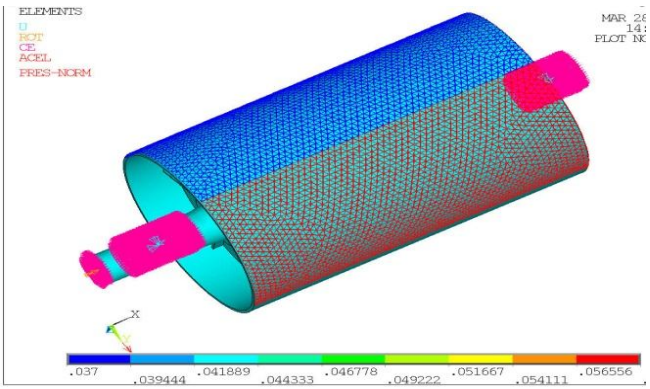

Figure.6. shows the Boundary Conditions of Rotor Shaft.

RESULTS:

The results obtained from the application of operating loads as discussed above are plotted. Deflections and stresses are shown below.

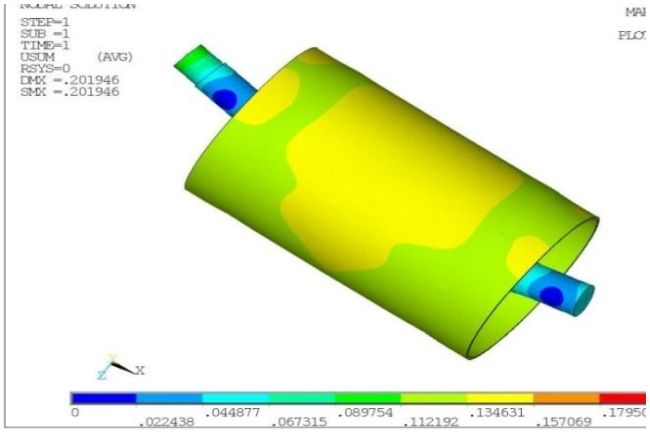

Figure.7. shows the Total deflection of rotor shaft assembly

MODEL ANALYSIS:

Model analysis is the first step of any vibration analysis. It is used to calculate the natural frequencies and mode shapes of the structure. From the model analysis the resonant frequencies can be determined and the location of low stiffness areas can be identified by plotting mode shapes. In general every structure has 'n' number of natural frequencies and this 'n' depend on the degree of freedom of the structure.

The first natural frequency is called as fundamental natural frequency. The natural frequencies depends on the geometry and material of the structure. Every natural frequency is associated with the mode shape. The mode shape is defined as the structure behaviour at a particular natural frequency.

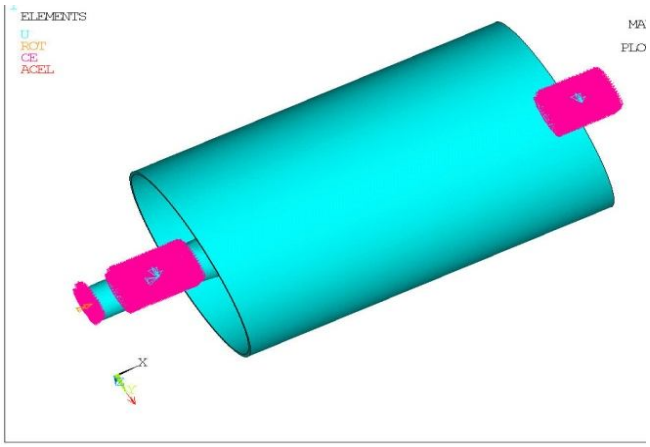

Figure.8. shows the Boundary conditions applied for model analysis

The first 10 natural frequencies and the mode shapes are shown in the below table.

Table.2. shows the first 10 natural frequencies and the mode shapes

Mode No.	Frequency (Hz)
1	51.48
2	84.529
3	84.54
4	97.82
5	213.1
6	213.14
7	380.33
8	380.34
9	450.56
10	450.58

The mode shapes at the corresponding frequency values are plotted below

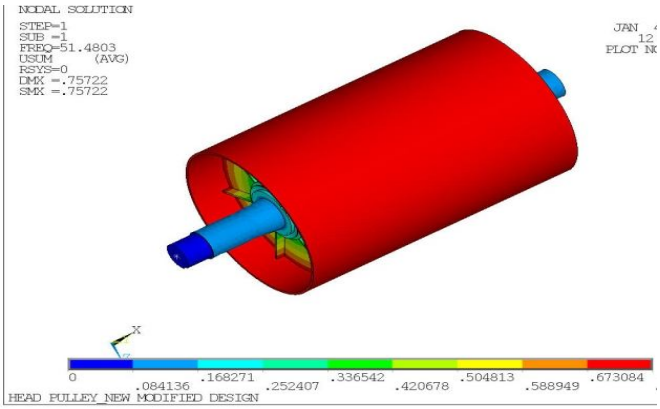

Figure.9. shows the mode shape @51.48 Hz

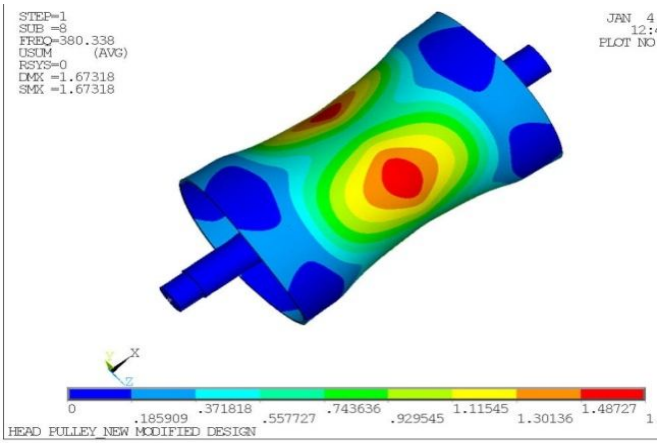

Figure.10. shows the mode shape@ 380.33 Hz

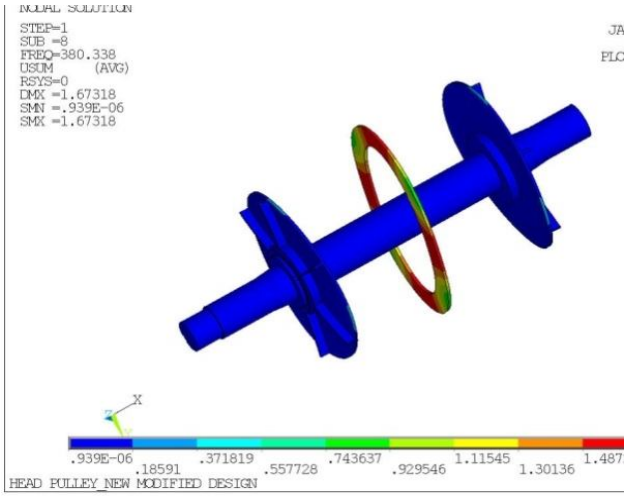

Figure.11. shows the mode shape@ 380.33 Hz

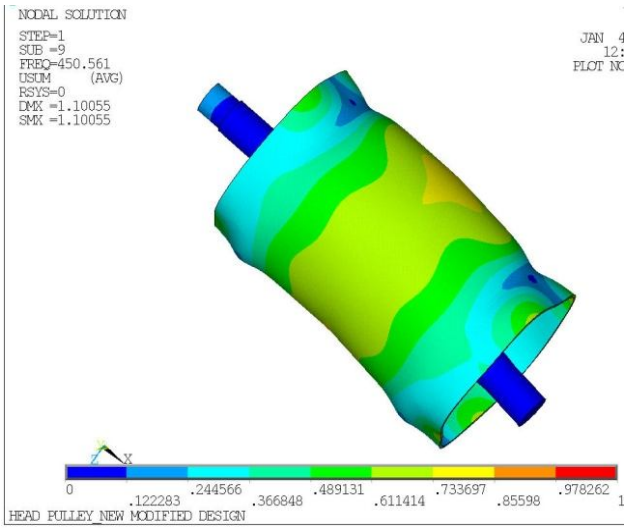

Figure.12. shows the mode shape@ 450.58 Hz

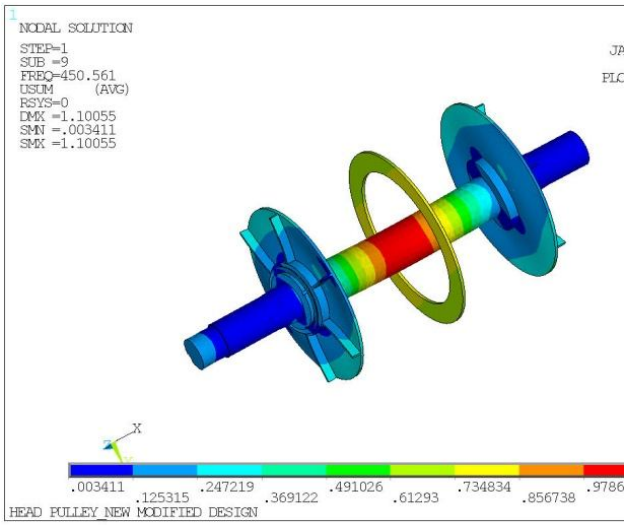

Figure.13. shows the mode shape@ 450.58 Hz

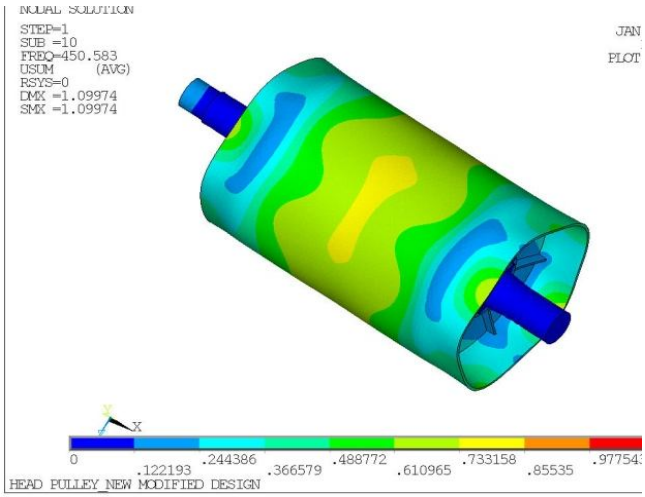

Figure.14. shows the mode shape@ 450.58 Hz

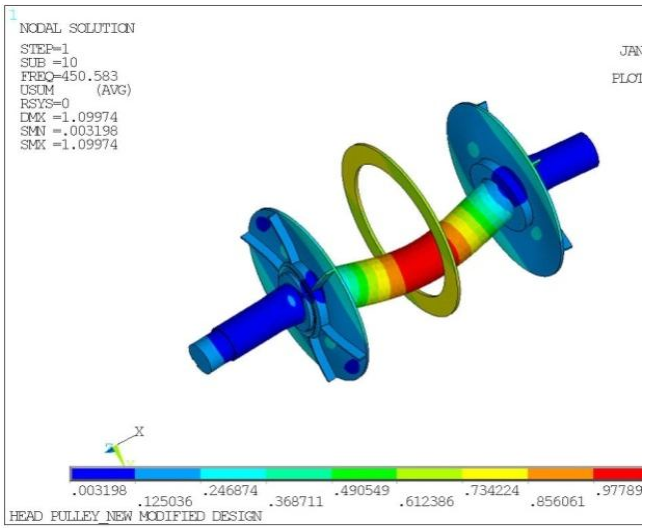

Figure.15. shows the mode shape@ 450.58 Hz

RESULTS:

From the static analysis we can observe that

- The maximum Vonmisses stress observed on the rotor shaft assembly is 44.59 Mpa.
- The maximum Vonmisses stress is observed on the hub ribs is 44.59 mpa.
- The maximum Vonmisses stress observed on the shaft is 26.29 Mpa.

IV. CONCLUSION

In this paper the design and analysis of rotor shaft assembly of a head pulley crusher has been done. It is very important to check whether the design is safe for the operating conditions are not before the prototype is made. The CAD and CAE tools are very useful for such kind of validation. In this paper the maximum deflection of 0.201 mm is observed on the

shaft and the maximum Von-mises stress of 44.5 Mpa is observed on the hub rib. The material used for the shaft rotor assembly is structural steel which is having yield strength as 250 Mpa. As maximum Vonmisses stress is less than the yield strength of the material, it is concluded that the design of rotor shaft assembly of head pulley crusher is safe for the operating loads. Model analysis was also performed to determine the vibration characteristics of the rotor shaft assembly and mode shapes are plotted.

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